I. Introduction

Typical communication channels
Signal types
Communication system elements
A/D & D/A conversion
Shannon's channel capacity theorem
Channel capacity

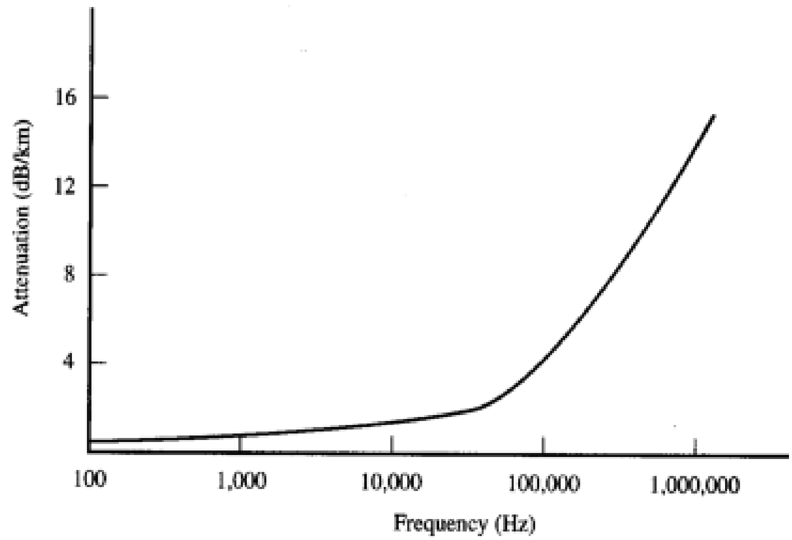
I. Introduction

1) Typical Communication Channels

- <u>Three traditional grades of channels</u>

Narrowband
Voiceband
Wideband

- <u>Channel attenuation issues</u>



Copper wire Attenuation versus Distance

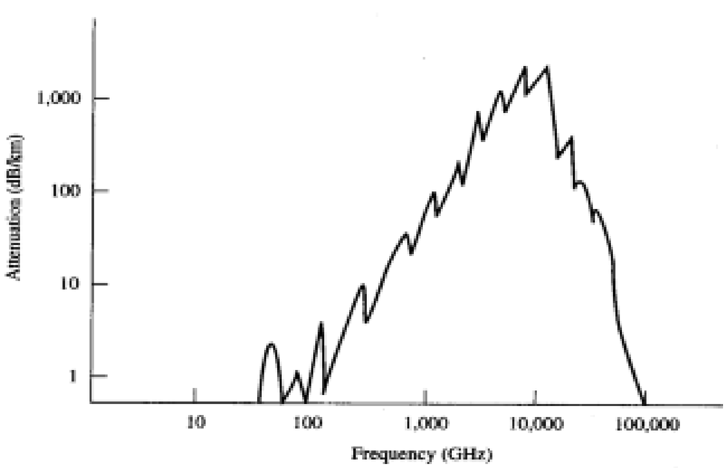


Figure 1.6 - Attenuation vs. Frequency

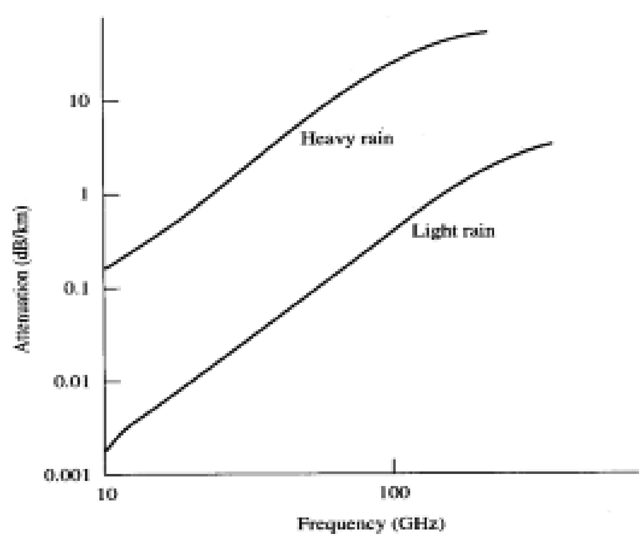


Figure 1.7 - Low Frequencies

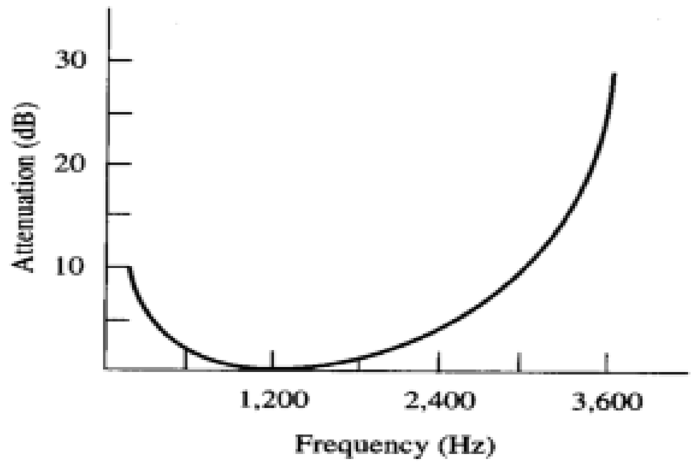


Figure 1.8 - Typical Telephone Channel Attenuation

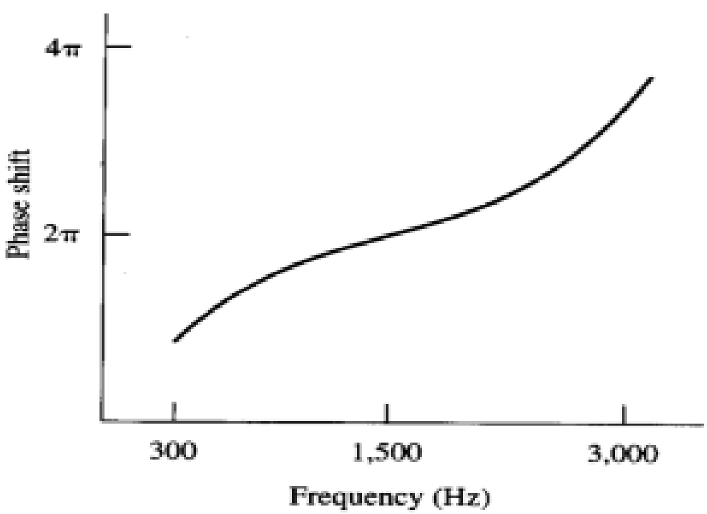
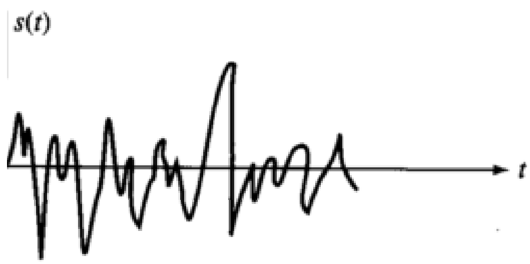
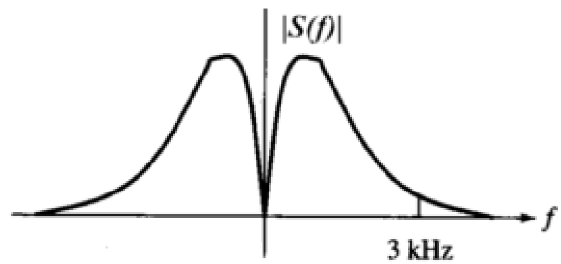


Figure 1.9 -Typical Telephone Channel Phase

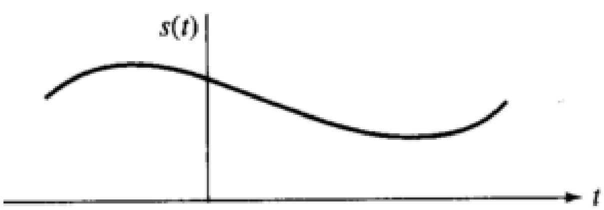
2) Signal Types

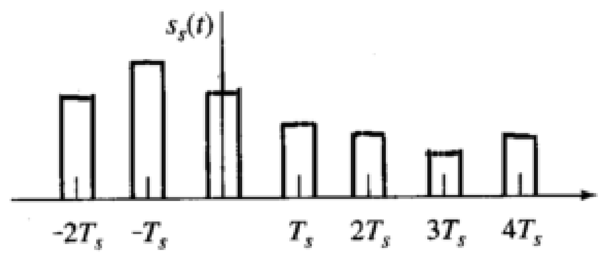
- <u>Analog signal</u>





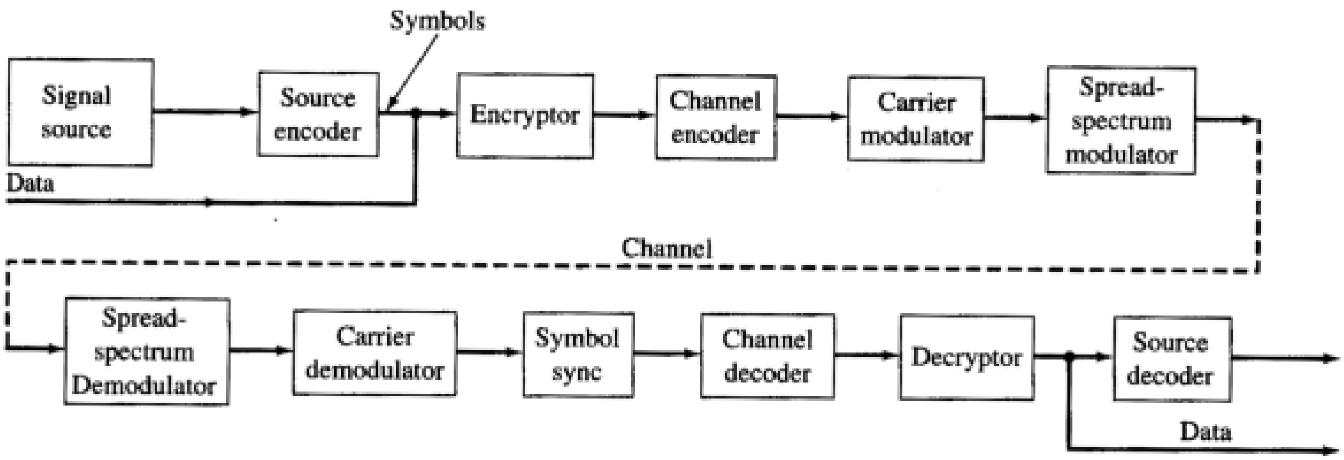
- <u>Analog sampled signal</u>



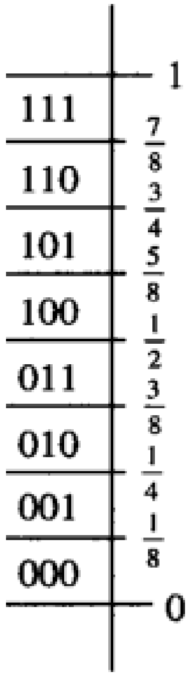


- <u>Digital signal</u>

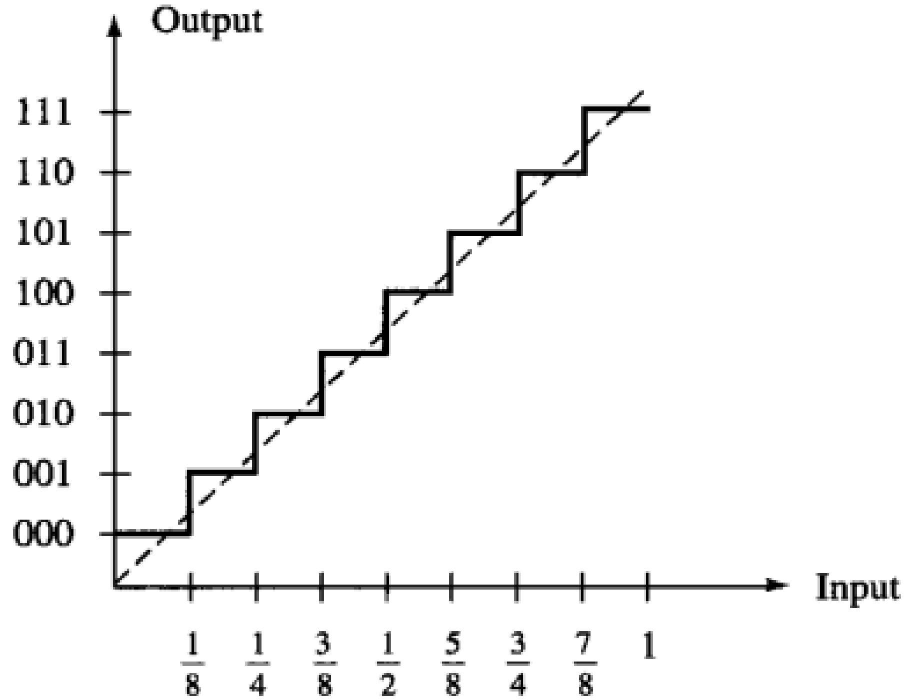
3) Communication System Elements



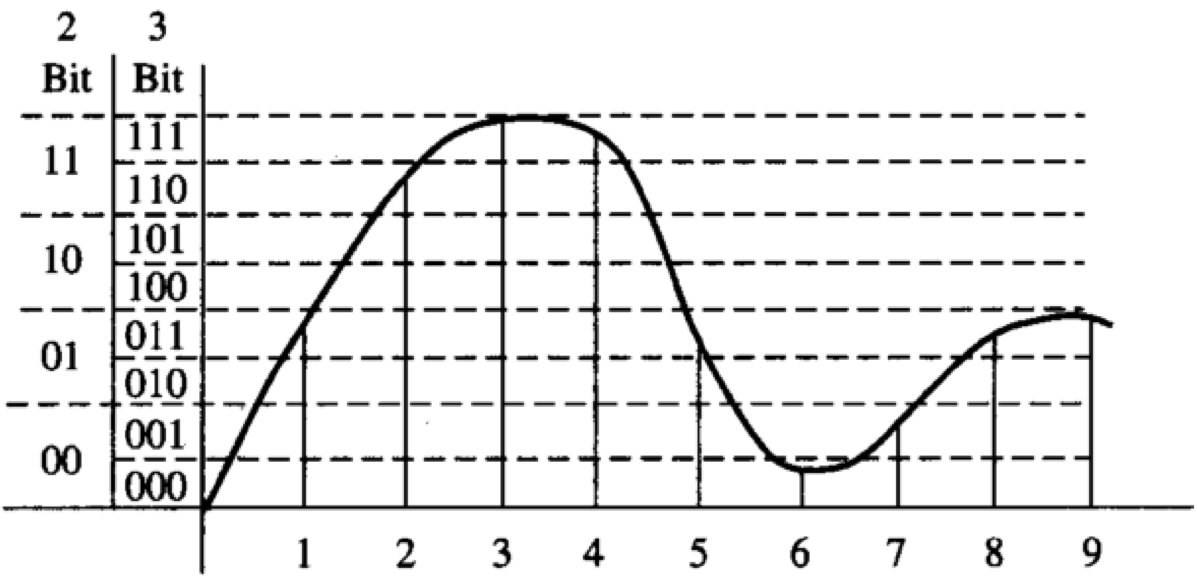
4) A/D and D/A Conversion



(a)



(b)



2-Bit	01	11	11	11	01	00	00	01	01
3-Bit	011	110	111	111	011	000	001	011	011

5) Shannon's Channel Capacity Theorm

- Shannon's theorem gives the maximum rate of information transmission $\rightarrow$ channel capacity

- Definition: Information content of a message x is defined as

$$I_x = \log_2 \frac{1}{P_x}$$

where P_x is defined as probability of occurrence of x

- Definition: Entropy is defined as the average information per message

$$H = \sum_{i=1}^{N} P_{x_i} I_{x_i} = \sum_{i=1}^{N} P_{x_i} \log_2 \left(\frac{1}{P_{x_i}} \right)$$

- Examples

  A communication system consists of four messages each with probabilities $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}$

  Find the entropy

- A communication system consists of two messages x_1 and x_2. Compute the entropy expression in terms of P_{x_1}

- <u>Channel capacity</u>

✶ Definition: The information rate (expressed in bits per second) is defined as:

$$R = r \quad H$$

message rate (1/*s*) entropy (bits/message)

✶ Definition

Channel capacity ⇔ maximum information rate

✶ Shannon-Hartley theorem: The channel capacity for a bandlimited channel operating in additive white Gaussian noise is given by:

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

where

B: channel bandwidth in Hz
S/N: SNR

✶ Shannon theorem comments

(1) B $\nearrow$

(2) SNR $\nearrow$

(3) $N = 0$

(4) $B \rightarrow +\infty$